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Research Document 2001/090

Document de recherche 2001/090

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Status of anadromous Dolly Varden (*Salvelinus malma*) of the Rat River, Northwest Territories, as assessed through community-based sampling of the subsistence fishery, August-September 1989-2000

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This document is available on the Internet at:

Ce document est disponible sur l'Internet à:

http://www.dfo-mpo.gc.ca/csas/

ISSN 1480-4883
Ottawa, 2001

Canada

Abstract

One or more stocks of anadromous Dolly Varden, known locally as "charr", inhabit the Rat River and its tributaries. Rat River Dolly Varden represent one of six known stocks of the northern form of Dolly Varden in Canada. The Dolly Varden that inhabit this system show a fair degree of genetic diversity, compared with stocks in neighbouring systems. Fishermen from two adjacent land claim groups, the Gwich'in and the Inuvialuit, harvest Dolly Varden from the Rat River stock(s). Communities of Aklavik and Fort McPherson developed and implemented their "Rat River Charr Fishing Plan" in 1995. The Plan recommends that the total take of Dolly Varden in the food fishery not exceed 2000 per year, and provides net number, size and depth restrictions. Compliance with the Plan has been improving over the past years, with fishing in the 1999 and 2000 seasons being in full compliance with the recommendations of the Plan. The fishery has been monitored through a community-based sampling program since 1989, expanded from one site to five sites in 1995, and continuing to the present day. The average annual harvest between 1990-1999 is equivalent to 13.0% of the 1998 estimate of stock size, and 17.7% of the 1996 estimate of stock size. There have been no detectable changes in the size of the Dolly Varden stock, as estimated over the past decade. There have been no declining trends in the Catch-Per-Unit-Effort, length- and age- frequency distributions, mean age and mean length, sex and maturity ratios of the Dolly Varden during the monitoring program between 1989-2000. The stock appears to be stable, and the outlook favourable, given careful monitoring of the stock, periodic estimation of the size of the stock, and compliance with the community-fishing plan.

Résumé

La rivière Rat et ses affluents abritent un stock ou plus de Dolly Varden anadrome, appelée localement « char » en anglais. La Dolly Varden de ce réseau constitue l'un de six stocks connus de la forme nordique de l'espèce au Canada. En plus d'être différente au plan génétique des populations des réseaux voisins, elle montre un niveau plus élevé de diversité génétique. Elle est exploitée par les pêcheurs de deux groupes voisins ayant fait une revendication territoriale, les Gwich'in et les Inuvialuit. Les villages d'Aklavik et de Fort McPherson ont élaboré et mis en oeuvre un plan de pêche de l'omble de la rivière Rat en 1995. Il y est présentement recommandé que les prises totales de Dolly Varden à des fins de subsistance ne dépassent pas 2 000 poissons par année; il y est aussi précisé le nombre de filets que chaque ménage peut tendre, leur dimension et les restrictions sur leur chute. La conformité au plan s'est améliorée dans les dernières années; les prises communautaires en 1999 et 2000 sont en pleine conformité aux recommandations énoncées dans le plan. La pêche fait l'objet d'une surveillance par la collectivité depuis 1989. Le programme d'échantillonnage que celle-ci met encore en oeuvre a été élargi en 1995, pour passer d'un à cinq sites. Les prises annuelles moyennes récoltées entre 1990 et 1999 équivalent à 13,0 % et 17,7 % de la taille estimative du stock en 1998 et 1996, respectivement. La taille du stock de Dolly Varden de la rivière Rat, telle qu'elle a été estimée au cours de la dernière décennie, n'a pas diminué. Pendant la période couverte par le programme de surveillance (1989-2000), les PUE (prises par unité d'effort), les distributions de la fréquence des longueurs et des âges, la proportion relative des sexes et le stade de maturité de la Dolly Varden de la rivière Rat sont demeurés relativement les mêmes. Le stock semble stable et la stratégie de pêche en vigueur ne le menace pas dans l'immédiat. Ses perspectives demeureront favorables si les prises continuent d'être surveillées de près chaque année, si des estimations indépendantes de la taille et de la composition du stock sont faites périodiquement et si le plan de pêche communautaire continue à être respecté.

Introduction

Dolly Varden *(Salvelinus malma)*, described by Reist (1989), inhabit the Rat River watershed. Spawning and over-wintering areas for Dolly Varden are located at spring-fed reaches of Fish Creek, a tributary of the upper Rat River. In the Western Canadian Arctic, Dolly Varden occur to the west of the Mackenzie River (e.g. in the Vittrekwa River of the upper Peel River drainage, the Big Fish River, the Babbage River, the Firth River, Joe Creek and the Rat River (Fig. 1). Arctic charr (*Salvelinus alpinus*) occur to the east of the Mackenzie drainage (e.g. Hornaday River, Kuujjua River).

In 1998, the size of the Rat River Dolly Varden stock was estimated to be 14,919 (95% CI 11,265-18,573; Harwood, L., unpubl. data). This was higher than the 1989 estimate of 11,191 (95% 8,532 - 15,020; Stephenson and Lemieux 1990) and the 1996 estimate of 9,679 (95% 8,194 – 11,158; Harwood, L., unpubl. data). Whether this represents a real increase in stock size is not known. Further mark-recapture studies are warranted to confirm this apparent trend.

Field observations (Sandstrom, S., unpubl. data) and preliminary genetic results (Reist, J., pers. comm.) suggest that the Dolly Varden that spawn and over-winter in the Rat River may comprise two or more different stocks. Observation of late season spawning activity (Harwood, L., unpubl. data), and fishermen's observations of two or more pulses in the fishery (Mitchell, B., pers. comm.), all suggest there is more than one stock of Dolly Varden using this basin.

Rat River Dolly Varden provide an important source of protein for the growing human population of Aklavik and Fort McPherson. The objective of the study was to assess the status of the stock and to describe the characteristics of the fishery, over the long term. From 1989-1994, the Dept. of Fisheries and Oceans hired one fisherman from Destruction City (Fig. 2) to enumerate, measure and sample his annual catch of Dolly Varden. Known locally as the "Charr (e.g. Dolly Varden) Monitoring Program", the study was expanded in 1995 to include all of the main fishing sites (including Destruction City) and has continued annually since that time.

Annual changes in the biological parameters and the success of the fishery, monitored over an extended period (e.g. a minimum of 10 years), provide a means by which to assess the status of the stock and the sustainability of the fishery. This monitoring program is only one of several Dolly Varden management initiatives underway by the harvesters of Fort McPherson and Aklavik.

Study Area

The Rat River straddles the Yukon-Northwest Territories border, and flows from headwaters in the Richardson Mountains along a 130 km (80 miles) course, entering the Husky Channel of the Mackenzie River 35 km (22 miles) north-west of Fort McPherson, NT (Fig. 1). Trees are confined to the valleys and lower slopes, and the rest of the basin area is covered by tundra vegetation. The bedrock is mainly sandstone, with some limestone in the northern sections. One tributary, Fish Creek, has many deep pools and is fed by one or more year-round springs. Water temperatures at the spring source area are in the 4-5 C^{o} range.

The high gradient rivers in this area cease flowing in the winter and freeze completely over much of their length. The exception to this is areas where groundwater springs enter. These perennial springs produce a system of "fish holes", areas that remain open year-round, and thus provide critical over-wintering and spawning habitat for the Dolly Varden. Downstream of the "fish holes", groundwater flows throughout the winter and this produces an aufeis (ice) field, also known as the "braided" area during ice-free periods. Spawning and over-wintering sites are relatively well known, and recent studies have documented that the physical characteristics of the "fish holes" do change over time, as sodium, water and silt levels fluctuate (Clark et al. 2001).

The Fishery

During the summer months, Rat River Dolly Varden are taken along the Beaufort Sea coast, mainly at whaling and fishing camps established along the Yukon coast and at Shingle Point. This is clearly a mixed-stock fishery, apparently with Dolly Varden from the Babbage, Firth, Big Fish and Rat, and presumably Vittrekwa river systems being caught here (Fig. 1). Alaskan fish are likely taken in this fishery as well.

Once the Rat River Dolly Varden begin their return migration to over-wintering and spawning areas, they encounter fishermen's nets at a number of locations along the way, usually between late August and mid-September (Fig. 2). These are the only times and places that Rat River Dolly Varden are harvested, with most of the fishing taking place for approximately 3-4 weeks each year. Floating, mono-filament gillnets with mesh 102 mm (4" and 114 mm (4 ½") are the most common sizes used, usually 25 m in length and 30 meshes deep. Smaller mesh nets (e.g. 89 mm or 3 ½") were used in the past, but have been largely discontinued since 1997.

Fishing sites (Fig. 2) include the mouth of the Big Fish River (traditionally fished by Inuvialuit of Aklavik but the area is presently closed to fishing for conservation reasons), the Aklavik townsite, the mouth of Husky Channel, Big Eddy along the Husky Channel, the confluence of Husky Channel and the mouth of the Rat River, and finally, Destruction City on the Rat River. There is apparently no fishing for Dolly Varden at the fish holes of Fish Creek on the Rat River at the present time. This practice apparently has not taken place since the mid-1980's (Francis, J., pers. comm.).

Methods

From 1989-1994, one fisherman was hired to sample, measure and enumerate his catches at Destruction City. In 1995, the program was expanded to five fishermen at each of five locations, including Destruction City. The program had four monitoring sites in 1999 and 2000. The fishermen that were hired, termed "monitors", were selected by the Aklavik and Fort McPherson Renewable Resource Councils (RRC's) , and started their work once the Dolly Varden began their upstream migration.

The monitors kept records of their own and nearest neighbours catches, to ensure that catches from all fishermen were represented in the study. The same monitors have been involved in the data collection at each site, throughout the six years of the study, with the exception of the mouth of the Rat River site where three different monitors were employed (JV in 1995-1997; LF in 1998-1999; BW in 2000).

Biological data from harvested fish that were collected prior to 1995, when the expanded monitoring program was first established, are useful but must be interpreted with caution as the amount of training and follow-up for certain aspects of the work (e.g. assessing sex and maturity) is not known. In addition, only one site was studied (as opposed to 4-5 in 1995-2000), so sample size is proportionately smaller.

The monitors were tasked with keeping records of the total number of Dolly Varden caught, as well as the number, length and mesh size of the gillnets used, and the location and duration of each set. The monitors were also tasked with sampling 100 Dolly Varden per season, throughout the fishery, for fork length, round weight, sex, maturity and stomach contents. The monitors were asked to select the fish for sampling randomly from the day's catch, and to spread the sampling effort throughout the fishery. In 2000, the monitors also took samples for future genetic analyses.

Sagittal otoliths were removed from all Dolly Varden sampled, and placed in a scale envelope for age determination. All age determinations were conducted by G. Carder of DFO's Freshwater Institute, according to Nordeng (1961). Any Dolly Varden caught in the fishery that had a floy or a radio tag was included in the sample. DFO biologists provided sampling materials and instructions prior to the start of each field season, and site visits during the course of the fishery.

Data Analysis

Size of Harvest and CPUE

To estimate the size of the annual harvest, the relevant data sets were compiled from the monitors, the Gwich'in Harvest Study, the Inuvialuit Harvest Study and the 1999 DFO Harvest Study (Stephenson, S., DFO Area Office). The total annual removal was estimated by summing:

- 50% of the Inuvialuit catch at Shingle Point the total of all Dolly Varden caught in the Peel Channel at Aklavik, by both Inuvialuit and Gwich'in fishermen
- the total of all Dolly Varden caught at Husky Channel and Big Eddy
- all Dolly Varden caught at the mouth of the Rat River and at Destruction City (Fig. 2).

The various data sets were compared to ensure all catches were included, and to ensure no duplication of records through reporting to more than one harvest study.

Catch per unit effort (CPUE) was calculated as the number of Dolly Varden/100 m/24 h. Annual records for individual monitors were examined and tabulated separately, and overall.

Mesh Size

Different mesh sizes are used in the fishery. The number of sets using each of 3.5, 4 and 4.5" mesh was tallied, and compared between years. Prior to 1995, mesh sizes of 3.5" were mainly used. An analysis of variance (ANOVA; Sokal and Rohlf 1995) was used to examine differences in the mean length of Dolly Varden caught with 4" and 4.5" mesh, for the 1998, 1999 and 2000 data sets, and for these three years pooled.

Biological Indicators

The mean fork length, round weight, ages and condition were calculated and tabulated for each year of the monitoring study, from 1989-2000. Data from the 1986 sampling of the subsistence harvest were also entered into the database and the same basic statistics were calculated (Sparling and Stewart 1986). The percentage of silvers (current year non-spawners), the percentage of male Dolly Varden, and the percentage of Dolly Varden in the sample >550 mm were calculated, for each year of the sampling.

The length-frequency distribution of the upstream migrants (sexes pooled) by 10 mm length class was constructed for the weir study (Gillman and Sparling 1985), for the hoopnet enumeration (Stephenson and Lemieux 1990), and for silvers for each year that the fishery was sampled (1989-2000). Age-frequency distributions of the upstream migrants caught in the fishery were also constructed for the same years.

An analysis of variance (ANOVA), available in SAS (1996) was used to compare the mean fork length of Dolly Varden caught in the fishery among years, by sex. A Duncan's Multiple Range Test was then used to elucidate which years were different. This same approach was used to compare mean age and body condition of Dolly Varden between years of the subsistence fishery.

A catch curve was constructed by plotting the running average of three age frequencies against log age. Instantaneous mortality rate (Z) was then calculated using a least squares regression on the descending limb of the catch curve. Only age groups that were fully recruited into the catch were used (7,8 or 9 through 11, 12 or 13 y) following Ricker (1975). Annual survival rate (S) and annual mortality rates (A) were also calculated.

Relative condition factor (K), a measure of the relative robustness of the fish, was determined by the following formula (Anderson and Gutreuter 1983):

$$K = \frac{W \times 10^5}{L^3}$$

where, W = round weight in g and L = fork length in mm.

Mean length at age was calculated for the weir assessment (Gillman and Sparling 1985) and for each year of sampling the harvest.

Results

The Harvest

The numbers of Dolly Varden known or estimated to have been harvested from the Rat River stock 1972-2000 are shown on Table 1. The average harvest of Rat River Dolly Varden for the past three decades, calculated from available data, was 3,733 Dolly Varden per year in the 1970's, 1,890 Dolly Varden per year in the 1980's and 1,953 Dolly Varden per year in the 1990's (Table 1). The estimates for the 1970's include catches from the Fish Hole in the early 1970's, and a small (<900 kg) commercial harvest in 1972 and 1973. The commercial quota of 900 kg was closed in 1985. Data from the 1980's and early 1990's may be partial in some cases, and during the 1970's, were collected opportunistically.

The average annual harvest between 1990-1999 is equivalent to 13.0% of the 1998 estimate of stock size, and 17.7% of the 1996 estimate. This rate of harvest appears to have been sustained by the stock, and is probably lower than it was in the 1970's. There is no fishing of this stock at the spawning or over-wintering sites. The Vittrekwa River Dolly Varden are likely contributing to the harvest now assigned to the Rat River, but to an unknown degree.

Timing of the Upstream Migration

The duration of the fishery averaged 34 days at the five monitoring sites, and ranged from 25 to 42 days. Patterns were similar between sites, within a given year. The mean date of the peak of the fishery was Aug 21 for the Husky Channel monitoring site, ranging from as early as August 2 in 1998, until as late as September 9 in 2000. The same pattern was evident at all other monitoring sites, with the earliest and latest peaks separated by more than one month. These data illustrate the inter-year variation characteristic of the timing of this fishery (Fig. 3).

Catch-Per-Unit-Effort (CPUE)

Between 1995 and 2000, the CPUE for the subsistence fishery averaged 38.1 Dolly Varden/100 m/24 h, but varied among years (range: 18.6 to 70.0 Dolly Varden/100 m/24 h; Table 2). The year with the highest overall and site-specific CPUE values was 1998, while the year with the lowest was 2000. The mean annual CPUE value given represents the same five fishermen employed as monitors, for five consecutive years, with the exception of the mouth of the Rat River site where the monitor changed twice but fished in the same area and time of year (see Table 2).

Catch-per-unit-effort (CPUE) can indicate changes in stock size, but at the same time, is greatly affected by changes in recruitment levels, timing of migrations, local environmental conditions and/or changes in fishing methods. In the subsistence fishery from 1995-2000, CPUE was relatively consistent (Table 2), with two exceptions. Mean CPUE for 1998 was nearly twice the average for the 1995-2000 period, while at the other extreme, the 2000 value was less than half the average. This is believed to be correlated with the timing of the runs in those years (Fig. 3), which was three weeks earlier than usual in 1998 and three weeks later than usual in 2000. Early and late runs appear to correspond with years of early and late break up of the ice, respectively.

Mesh Size

The mean length of Dolly Varden caught with 102 mm (4") nets was 488 mm (n=316), whereas the mean length of Dolly Varden caught with 114 mm (4.5") nets was 523.8 mm (n=182). These differences were significant, both overall ($F=60.81$, $DF=1,1585$; $p<0.0001$) and when the years were considered separately (1998, $F=55.14$, $DF=1,658$, $p<0.0001$; 1999, $F=16.46$, $DF=1,428$, $p<0.0001$; 2000, $F=42.02$, $DF=1,497$, $p<0.0001$).

However, the number of sets made by the monitors using 102 mm (4") and 114 mm (4.5") nets remained relatively consistent between years (Table 3), with 102 mm predominating (used in 60-80% of all sets) in all years for which data are available. The increase in size of the Dolly Varden caught in 1999 and 2000 (Fig. 4) did not coincide with an increase in the use of larger mesh nets.

Biological Indicators

The length-frequency distributions of fish caught in the weir enumeration (1983), the hoopnet study (1989), and the Fish Hole seining studies (1995 and 1997) are shown on Figure 4. Modal lengths remained similar during this period, with bimodal distributions in 1983 (320 mm and 410 mm) being similar to bi-modal distribution in 1989 (320 mm and 420 mm). For the seining work at the Fish Hole in fall 1995 and 1997, the smolts are not available to the survey due to timing (Harwood, L. unpubl. data) which explains why there is no peak in the distribution in the 310-320 mm intervals. However, the second mode, representing the adult fish present in the surveys, can be compared among years. The 1995 mode (460 mm) is similar to the 1997 mode (430 mm), which are both larger than that from the 1983 (410 mm) and 1989 (420 mm) studies.

Sampling of the Dolly Varden harvests at Destruction City (1986-1994), and at five monitoring sites including Destruction City (1995-2000) (Fig. 1) provides a long-term record of size, sex, age and condition of Dolly Varden taken in the fishery. A truncated stock distribution, a decrease in the number of large fish, or changes in age structure could indicate a downward trend in the stock.

The largest Dolly Varden caught and recorded from this fishery was 694 mm (27.3"), from Husky Channel in 2000. This fish was estimated to be 6 y of age. The modal size class of Dolly Varden from this fishery is 430 mm, and the mean 436.8 mm (n=5,465).

There was a wide range of sizes of Dolly Varden taken in the harvest in each year of the fishery, and this did not appear to change over time (Fig. 5). Results are consistent with the earlier data as well (Sparling and Stewart 1986).

The mean annual fork length of male and female Dolly Varden taken in this fishery was significantly different between years (ANOVA, females, $F=105.6$, $DF=12, 3422$, $p<0.0001$; males $F=67.88$, $DF=12, 1820$, $p<0.0001$). The mean length of males and females was significantly greater in 1999 and 2000 than in the other 11 years examined. For both males and females, the year with the lowest mean length, for both sexes, was 1993.

There has been an upward trend in the size of Dolly Varden caught in the fishery (Fig. 5) up to and including 2000. For 1999 and 2000, this increase was statistically significant. This was thought to be related to increased growth in those years, following an exceptionally productive season in 1998, and/or the result of reduced fishing pressure.

The percent of Dolly Varden greater than 550 mm in the sample was within the range from 0.6-6.0 up to and including 1998. In 1999 and 2000, the proportion >550mm increased dramatically, to 20.4% and 20.2%, respectively (Table 4). At the hoop-net enumeration in 1989, the proportion of Dolly Varden that were >550mm in length was <1% (3/505; Stephenson and Lemieux 1990). The fishery clearly removes the larger, older fish from the stock.

Age

The oldest Dolly Varden caught in the 1986-2000 subsistence fishery was 12 years The youngest Dolly Varden in the database was 2 years old. The modal age was 6 y, and the overall mean age was 5.82 y (n=4230).

The mean age of male and female Dolly Varden taken in the fishery between 1986 and 2000 varied between years (ANOVA, females, $F=24.84$, $df=12, 2709$, $p<0.001$; males, $F=22.17$, $df=12, 1459$, $p<0.0001$). However, there were no consistent trends toward increasing or decreasing mean age over the 1995-2000 period (Table 4). The age-frequency distributions of migratory Dolly Varden at the Rat River (Fig. 6) show weak representation of the older age classes in recent years.

Sex and Maturity

Silvers are caught more often than spawners in this fishery (Fig. 7), and females outnumber males by approximately 2 to 1 (Table 4). The proportion of silver Dolly Varden caught in the fishery averaged 76.4% between 1989 and 2000, ranging from a high of 98.4% in 1993, to a low of 41.6% in 1999. There was a slight increased take of current year spawners in the 1999 and 2000 catch. This is could be due to an increase in the proportion of current year spawners due to excellent feeding conditions in 1998.

The sex ratio of the catch has remained similar throughout the six years of the core monitoring program. On average, 35.8% were males (range: 30-43%; Fig. 8). There were no obvious temporal trends toward changes in the sex ratio of the catch (Table 4).

Growth and Condition

During the 1995-2000, the average weight for a Dolly Varden was 1,427 g, or about 3.1 lb. The maximum weight of a Dolly Varden recorded by the monitors was 5,450 g (12 lb).

The condition of the Dolly Varden caught in the fishery was calculated according to the equation K = weight (g) x 10^5 /length $(mm)^3$ (Anderson and Gutreuter1983). Condition varied significantly between years (ANOVA, females, $F=81.26$, $df=10, 2734$, $p<0.001$; males $F=27.79$, $df=10, 1494$, $p<0.0001$), with both male and female Dolly Varden having significantly higher K values in 1998 than in any of the other years examined. However all were lower than 1998 (Fig. 9).

The condition of the upstream migrants reflects the quality and quantity of food available during summer feeding in the ocean, and as such, changes in condition are not considered to be direct responses of the stock to harvesting. In spring 1998, regional ice conditions were light and break-up was early, and this is thought to have resulted in particularly favourable feeding conditions in the ocean that summer.

Mean length-at-age for the monitoring period has been tabulated along with that from the stratified dead sample from the 1983 weir study (Table 5). Trends are difficult to assess because of the size variation within any given age class. However, the mean length-at-age has generally been increasing in recent years. This aspect should continue to be monitored. The growth rate of Rat River Dolly Varden is higher than that of Dolly Varden from neighbouring systems on the North Slope (Sandstrom 1995).

Recaptured tagged Dolly Varden from 1998 also showed high growth rates. Mean annual growth of Dolly Varden (450-600 mm) tagged in 1997 and recaptured in late summer 1998 was 75.9 mm (n=9), over an 11 month period. In contrast, the growth rate of (450-600 mm) Dolly Varden tagged in 1995 and recaptured in late summer 1996 averaged 31.2 mm (n=32) for the same length of time. In addition, fishermen observed differences in the timing and composition of the upstream run in 1998, compared with their general impressions of other years of the fishery (Mitchell, B., personal observation).

Spawning Frequency

Of eight adult charr that were tagged as spawners in 1997 and recaptured in 1998, 6 (75%) returned as silvers (e.g. were taking a resting year), and 2 (25%) returned as spawners again. The two that returned as spawners we are calling "sequential spawners", and both of these were large females (562 mm and 575 mm), and were the first and third largest of the eight charr. As in 1996, these data suggest that a small proportion of the mature charr spawn in consecutive years (primarily the larger, older ones), while the balance take a "resting" year in between spawning years.

Mortality

Instantaneous mortality rate, calculated from the catch curve for ages 7-11 y, was 0.94 in 1989. Rates tended to be higher during the 1990's, ranging from a low of 0.44 (7-12 y) in 1994 to a high of 2.63 (8-9 y) in 1998 (Table 6).

In summary, a number of stock indicators suggest the following in regard to stock status:

- stable or increasing estimates of stock size
- stable estimates of annual CPUE, overall and at individual sites
- wide range of age and length in the frequency distributions from the fishery
- broad age- and length-frequency distributions at the spawning and over-wintering site
- no apparent change in the age and length frequency distributions
- unchanged sex and maturity ratios

These indicators suggest that the Rat River Dolly Varden stock is stable and that the present harvest is being sustained by the stock. Additional sampling of the newly recruited juveniles (smolts) would contribute further to our understanding of stock trends, and this is planned for 2001.

Summary

- One or more stocks of anadromous Dolly Varden, known locally as "charr", inhabit the Rat River and its tributaries.

- Fishermen from two adjacent land claim groups, the Gwich'in and the Inuvialuit, harvest Dolly Varden from the Rat River stock(s). Communities of Aklavik and Fort McPherson developed and implemented their "Rat River Charr Fishing Plan" in 1995.

- The Plan recommends that the total take of Dolly Varden in the food fishery not exceed 2000 per year, and provides net number, size and depth restrictions.

Compliance with the Plan has been improving over the past years, with fishing in the 1999 and 2000 seasons being in full compliance with the recommendations of the Plan.

- The fishery has been monitored through a community-based sampling program since 1989, expanded from one site to five sites in 1995-1998, and continuing at four sites in 1999 and 2000, and to the present day.

- The average annual harvest between 1990-1999 is equivalent to 13.0% of the 1998 estimate of stock size, and 17.7% of the 1996 estimate of stock size.

- There have been no detectable changes in the size of the Dolly Varden stock, as estimated over the past decade. There has been no declining trend in the CPUE, length- and age-frequency distributions, mean age and mean length, sex and maturity ratios of the Dolly Varden during the monitoring program between 1989-2000.

- The stock appears to be stable, and the outlook favourable, given careful monitoring of the stock, periodic estimation of the size of the stock, and compliance with the community fishing Plan.

Community Based Initiatives to Conserve the Stock(s)

In recent years, biological indicators and reports from the local people that harvest Rat River Dolly Varden for food suggest that removals may have been more than the stock(s) could sustain. It does appear that fishing during the 1970's and 1980's, which included commercial and subsistence fishing, has led to the progressive removal of the largest and oldest fish. This was the catalyst for the development and implementation of the Rat River Charr Fishing Plan in 1995 (Aklavik et al. 2000). The highlights of the Plan include harvest and gear restrictions. The communities have complied with the Plan for the past two years.

It is recommended that the basic annual monitoring and sampling program continue, to (1) monitor the status of the stock, (2) collect the relevant data to manage the stock, and (3) monitor compliance with the Rat River Dolly Varden Fishing Plan.

Acknowledgments

The work and dedication of the monitors, Selwyn Kay (12 years), the late Joe Vittrekwa (3 years), Lazarus Francis (1 year), Billy Wilson (1 year), John Carmichael (6 years), Ben Mitchell (6 years) and Dale Semple (3 years) is duly acknowledged. The staff of the Fort McPherson and Aklavik RRC's assisted with program administration, particular Liz Wright and George Nerysoo. The data could not have been collected without the support of the RRC's and the people of Aklavik and Fort McPherson, who allowed their catches to be enumerated and sampled.

All of the Dolly Varden were aged by Gary Carder, formerly of DFO, presently resident in Salmon Arm, BC. The 1989-1994 programs were co-ordinated by L. Dahlke of DFO. Ian McLeod and Steve Sandstrom assisted with program delivery in 1996 and 1995, respectively. Lynn Isenor, Mari Raddi and Julia Kenyon assisted with data entry and proofing. Al Kristofferson (DFO) has provided advice and support over the years in the planning and conduct of this and other related projects, and provided thoughtful reviews of this and earlier manuscripts. The work was funded by the Gwich'in Renewable Resources Board and by DFO.

References

Aklavik RRC, Fort McPherson RRC and Aklavik HTC. 2000. Rat River Charr Fishing Plan. Available: Dept. of Fisheries and Oceans, Box 1871, Inuvik, NT Canada, X0E 0T0.

Anderson, R.O. and S.J. Gutreuter. 1983. Length, weight and associated structural indices. pp. 283-300, *In*: Fisheries Techniques. L. A. Nielsen and D. L. Johnson, eds. American Fisheries Society, Bethesda, Maryland.

Clark, I.D., B. Lauriol, L. Harwood, and M. Marschner. 2001. Groundwater contributions to discharge in a permafrost setting, Big Fish River, N.W.T., Canada. Arctic, Antarctic and Alpine Research, Vol. 33, No. 1, pp. 62-69.

Fabijan, M. 1991a. Inuvialuit Harvest Study Data Report (January 1986-December 1988). Box 2120, Inuvik, NT Canada. X0E 0T0

Fabijan, M. 1991b. Inuvialuit Harvest Study Data Report (January 1989-December 1989). Box 2120, Inuvik, NT Canada. X0E 0T0

Fabijan, M. 1991c. Inuvialuit Harvest Study Data Report (January 1990-December 1990). Box 2120, Inuvik, NT Canada. X0E 0T0

Fabijan, M. 1995a. Inuvialuit Harvest Study Data Report (January 1991-December 1991). Box 2120, Inuvik, NT Canada. X0E 0T0

Fabijan, M. 1995b. Inuvialuit Harvest Study Data Report (January 1992-December 1992). Box 2120, Inuvik, NT Canada. X0E 0T0

Fabijan, M. 1995c. Inuvialuit Harvest Study Data Report (January 1993-December 1993). Box 2120, Inuvik, NT Canada. X0E 0T0

Fabijan, M. 1995d. Inuvialuit Harvest Study Data Report (January 1994-December 1994). Box 2120, Inuvik, NT Canada. X0E 0T0

Fabijan, M. 1997a. Inuvialuit Harvest Study Data Report (January 1995-December 1995). Box 2120, Inuvik, NT Canada. X0E 0T0

Fabijan, M. 1997b. Inuvialuit Harvest Study Data Report (January 1996-December 1996). Box 2120, Inuvik, NT Canada. X0E 0T0

Fabijan, M. 1998. Inuvialuit Harvest Study Data Report (January 1997-December 1997). Box 2120, Inuvik, NT Canada. X0E 0T0

Gillman, D.V. and P.D. Sparling. 1985. Biological data on Arctic charr, *Salvelinus alpinus* (L.).from the Rat River, Northwest Territories, 1983. Canadian Data Report Fisheries and Aquatic Sciences 535: iv + 15p.

McDonald, I. 1998a. Gwich'in Harvest Study Data Report, August 1995-December 1996. Prepared by the Gwich'in Renewable Resources Board, Box 2240, Inuvik, NT Canada X0E 0T0.

McDonald, I. 1998b. Gwich'in Harvest Study Data Report, 1997. Prepared by the Gwich'in Renewable Resources Board, Box 2240, Inuvik, NT Canada X0E 0T0.

Nordeng, H. 1961. On the biology of charr (*Salmo alpinus L.*). *In*: Salangen, North Norway. 1. Age and spawning frequency determined from scales and otoliths. Nytt Mag. for Zool. 10: 67 - 123.

Reist, J. D. 1989. Genetic structuring of allopatric populations and sympatric life history types of charr, *Salvelinus alpinus/malma*, in the western Arctic, Canada. pp 405-420, *In:* H. Kawanabe, F. Yamazaki and D.L.G. Noakes, eds., Biology of charrs and masu salmon: Proceedings of the International Symposium on charrs and Masu Salmon. Physiol. Ecol. Japan, Spec. Vol. 1.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada 191. Dept. of Fisheries and Oceans, 200 Kent St., Ottawa, Ontario, Canada.

Sandstrom, S. J. 1995. The effect of over-wintering site temperature on energy allocation and life history characteristics of anadromous female Dolly Varden (Salvelinus malma), from north-western Canada. M.Sc. Thesis, University of Manitoba, Winnipeg, MB. 161pp.

SAS (Statistical Analysis System). 1996. SAS Users guide: Statistics Version 6. SAS Institute Inc., Cary, NC.

Sokal, R.R. and F. J. Rohlf. 1995. Biometry. Third Edition, W.H. Freeman and Company, California. 887p.

Sparling, P. J. and D.B. Stewart. 1986. Data from the monitoring of domestic/commercial fisheries for Arctic charr in the Big Fish River and Rat River areas, Northwest Territories, 1986. Fisheries Joint Management Committee Report No. 86-002. 28 p. Available: FJMC, Box 2120, Inuvik, NT, Canada. Prepared by Arctic Biological Consultants, Pinawa, MB.

Stephenson, T. and P. J. Lemieux. 1990. Status of the Rat River charr population, 1989. Fisheries Joint Management Committee (FJMC) Report No. 89-008. 62 p. Available: FJMC, Box 2120, Inuvik, NT, Canada. Prepared by Dept. of Fisheries and Oceans, Box 1871, Inuvik, NT Canada.

Table 1. Estimated harvest of Rat River Dolly Varden, 1972-2000

Year	Inuvialuit harvest Aklavik[1,4]	50% of Inuvialuit harvest from Shingle Pt[1,4]	Gwich'in Harvest[2,3]	Unspecified claim area harvest[5,6]	Total est. harvest	Average of available data, that decade
1972				6500	6500	
1973				2600	2600	
1975				2100	2100	3733
1980				1545	1545	
1986		50		1050	1100	
1987		125		3000	3125	
1988		74		1607	1681	
1989	132	53	1814		1999	1890
1990	60	107	884		1051	
1991	20	3	353		376	
1992	250	9	775		1034	
1993	381	60	968		1409	
1994	842	17	1296		2155	
1995	377	32	1115		1524	
1996	547	403	1970		2920	
1997	643	62	2688		3393	
1998	255	386	3119		3760	
1999	225	125	1561		1911	1953
2000	8	0	1485		1493	1493

[1] Inuvialuit Harvest Study (Fabijan 1991a,b,c; Fabijan 1995 a,b,c,d; Fabijan 1997a, b; Fabijan 1998) for all years listed except 1999

[1] Inuvialuit Harvest Study (Fabijan 1991a,b,c; Fabijan 1995 a,b,c,d; Fabijan 1997a, b; Fabijan 1998) for 1986-1994

[3] Gwich'in Harvest Study (McDonald 1998 a,b) and this study for 1995-2000

[4] DFO Fish Harvest Study (S. Stephenson, unpublished data) for 1999

[5] DFO files, R. Peet, G. Lowe, unpublished data

[6] Thought to include commercial harvests in 1972, 1973 and 1975

Table 2 Mean annual CPUE (# Dolly Varden/100 m/24 h) at harvest sampling and monitoring sites, 1995-2000

Year	All Sites	Aklavik			Husky Channel			Big Eddy			Rat River mouth*			Destruction City		
	mean CPUE	mean CPUE	duration of fishery (days)	Peak	mean CPUE	duration of fishery (days)	Peak	mean CPUE	duration of fishery (days)	Peak	mean CPUE	duration of fishery (days)	Peak	mean CPUE	duration of fishery (days)	Peak
1995	21.0	-	-	-	21.0	25	Aug 22	-	-	-	-	-	-	-	-	-
1996	30.6	8.9	20	Aug 26	27.1	31	Aug 24	33.9	31	Aug 23	13.2	29	Aug 27	51.9	32	Aug 25
1997	45.2	42.8	21	Aug 27	54.0	29	Aug 27	44.8	30	Aug 22	66.5	31	Aug 24	35.0	29	Sep 1
1998	74.0	62.7	25	Aug 18	36.7	40	Aug 2	71.1	39	Aug 12	117.2	26	Aug 9	87.5	36	Aug 22
1999	39.4	-	-	-	14.7	42	Aug 16	37.1	36	Sep 1	93.1	30	Aug 11	41.6	33	Sep 6
2000	18.6	-	-	-	18.8	41	Sep 9	22.6	40	Sep 8	11.1	39	Sep 13	23.1	38	Sep 16

* same monitor at each site in all years, except mouth of the Rat River where three different monitors were involved over the years but all fished at the same location using similar gear

Table 3. Gillnet mesh sizes used by monitors for catching Rat River Dolly Varden, 1995-2000

Year	No. of monitors in sample	Mesh Size			Total no. of sets	Percent of sets using 102 mm
		89 mm 3.5"	102 mm 4.0"	114 mm 4.5"		
1995	1		26		26	100.0
1996	5	8	220	130	358	61.5
1997	5	6	289	62	357	81.0
1998	5		118	102	220	53.6
1999	4		137	91	228	60.1
2000	4		237	76	313	75.7

Table 4. Summary of CPUE, sex, maturity, length, age and weight parametersdetermined from the 1989-1994 subsistence fisheries at Destruction City, and at the fishery monitoring sites including Destruction City, 1995-2000.

Year	No of fishermen	Estimated total harvest	mean CPUE* monitors pooled	Percent silvers	Percent males	mean fork length (mm)		Percent of sample	mean age (y)		mean condition (K)	
						females n=3423	males n=1821	>550 mm	females n=2710	males n=1460	females n=2735	males n=1495
1989	nd	1999	nd	51.4	23.5	423.5	384.9	0.6	6.4	5.6	1.13	1.18
1990	nd	1051	nd	71.9	37.9	391.8	386.5	3.0	4.9	4.8	1.22	1.24
1991	nd	376**	nd	91.1	42.9	430.0	398.5	1.6	5.0	4.5	1.04	1.17
1992	nd	1034	nd	nd	nd	452.2	440.5	2.3	6.3	5.7	1.05	1.06
1993	nd	1409	nd	98.4	36.5	364.9	358.2	0.6	5.4	5.2	1.36	1.38
1994	nd	2155	nd	93.5	30.3	426.2	439.6	2.0	5.9	5.8	nd	nd
1995	15	1524	21.0	83.5	35.3	437.0	430.3	3.9	6.2	6.0	nd	nd
1996	14	2920	30.6	68.7	33.1	451.7	425.0	6.0	5.8	5.1	1.48	1.41
1997	19	3393	45.2	90.9	36.1	412.2	417.0	1.9	5.8	5.7	1.38	1.43
1998	18	3760	74.0	83.9	40.6	438.3	449.4	6.0	5.8	5.8	1.87	1.75
1999	23	1911	39.4	41.6	39.5	498.3	509.8	20.4	6.3	6.1	1.45	1.43
2000	19	1493	18.6	68.8	37.8	498.1	506.0	20.2	6.1	5.9	1.22	1.18
Average	18	2059	38.1	76.7	35.8	435.3	428.8	5.7	5.8	5.5	1.3	1.3

* CPUE = # of Dolly Varden/100 m net/24 h
** incomplete estimate

Table 5. Mean length-at-age of Dolly Varden from the Rat River weir study (1983) and from the subsistence fisheries, 1986-2000

Age	1983 weir	1986	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
		subsistence fishery												
1														
2	**298.0**													
3	**294.5**	304.1	337.9	341.4	360.0					365.3	379.0	**381.0**	**420.0**	**457.0**
4	337.1	334.3	357.4	351.0	388.0	393.2	328.6	407.6	351.7	395.1	345.7	405.6	447.6	446.3
5	408.0	383.6	370.3	396.7	432.6	422.0	351.9	400.4	388.3	414.3	389.1	409.7	478.7	471.2
6	450.6	407.8	414.6	429.9	434.3	451.4	382.9	421.4	435.8	458.0	422.9	445.4	497.6	503.0
7	496.8	**508.7**	457.2	470.7	492.3	469.0	390.2	448.4	466.9	492.7	466.2	493.8	525.7	527.1
8	497.1	**565.0**	478.0	**511.3**		504.1	**487.0**	**543.0**	506.8	527.2	517.5	521.4	554.6	543.0
9	**538.7**		493.1			500.3			**496.8**	548.0	**528.0**	**605.0**	**516.0**	543.2
10	**600.5**		**533.8**						**500.0**	**591.5**				**557.4**
11			**553.0**			**534.0**		**550.0**		**564.0**	**542.0**			
12														

* mean lengths shown in bold are from n<5 fish

1983- Gillman and Sparling 1985; 1986 - Sparling and Stewart 1986; 1989 - Stephenson and Lemieux 1990; 1990-2000, this study

Table 6. Rat River Dolly Varden instantaneous mortality rate (Z), annual survival rate (S) and annual mortality (A)

Year	Depvar	Intercept	Slope	Z	S	A	Indep Var	Ages Used
1989	ln_freq	11.0673	-0.94465	0.94465	0.38882	0.61118	age	7-11
1992	ln_freq	7.5833	-0.62638	0.62638	0.53452	0.46548	age	9-11
1993	ln_freq	14.3341	-1.79176	1.79176	0.16667	0.83333	age	7-8
1994	ln_freq	5.0765	-0.44793	0.44793	0.63895	0.36105	age	7-12
1995	ln_freq	16.5476	-1.66394	1.66394	0.18939	0.81061	age	7-10
1996	ln_freq	11.7302	-1.07928	1.07928	0.33984	0.66016	age	8-11
1997	ln_freq	5.3753	-0.51193	0.51193	0.59934	0.40066	age	8-11
1998	ln_freq	23.7515	-2.63906	2.63906	0.07143	0.92857	age	8-9
1999	ln_freq	20.1013	-2.07944	2.07944	0.12500	0.87500	age	8-9
2000	ln_freq	15.3285	-1.50408	1.50408	0.22222	0.77778	age	8-10

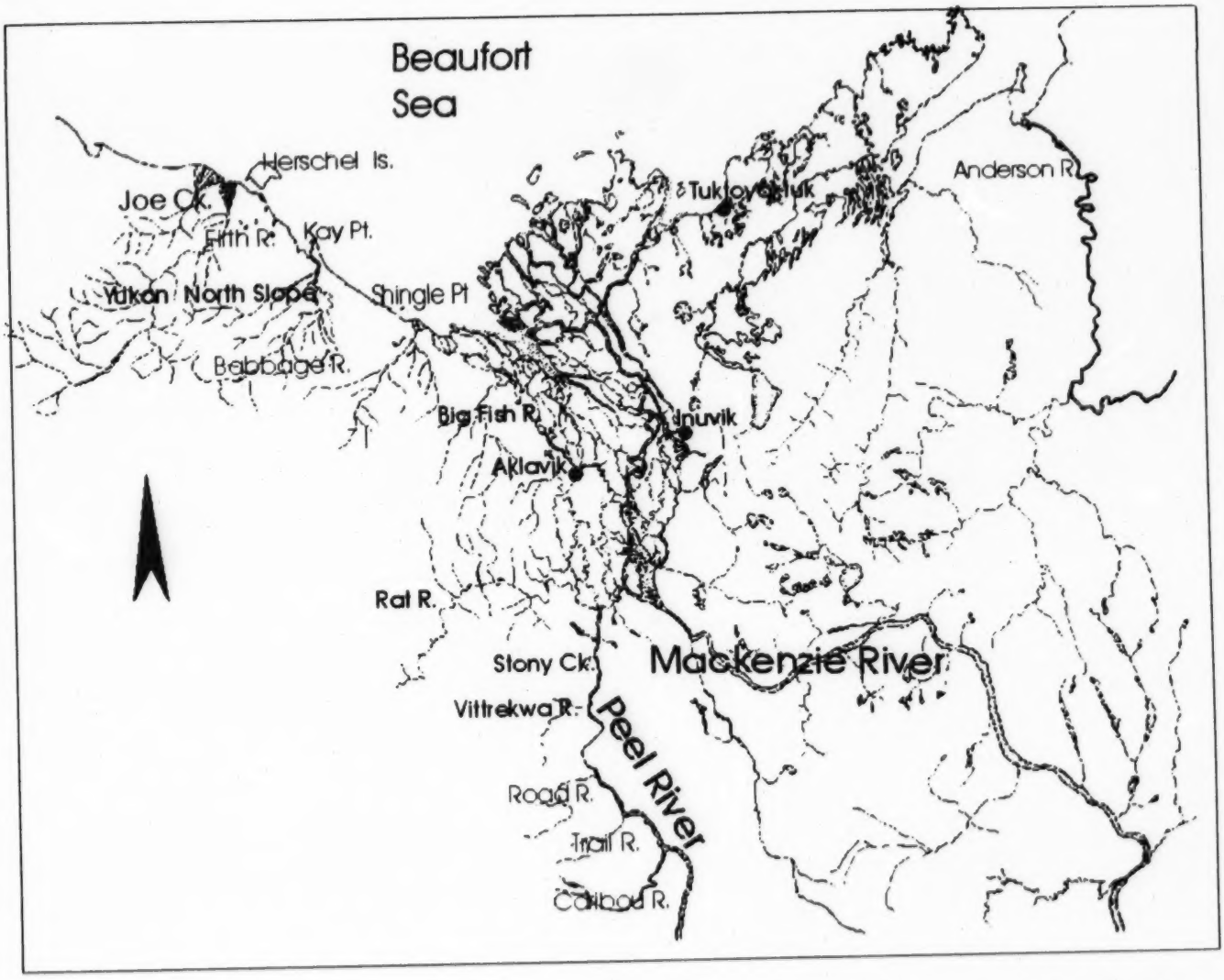

Fig. 1. The lower Mackenzie River and Yukon North Slope

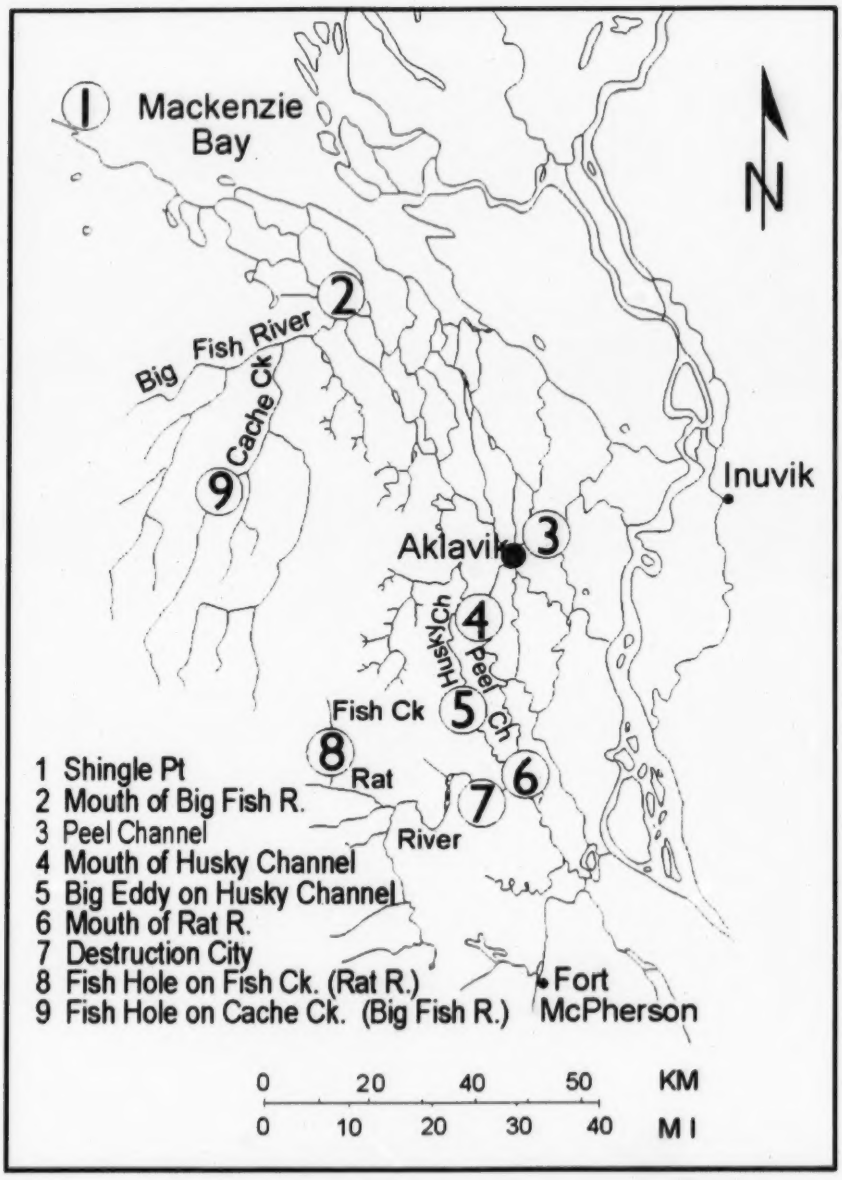

Fig. 2. Fishing sites for Rat River Dolly Varden and spawning and over-wintering sites for Rat River and Big Fish River Dolly Varden.

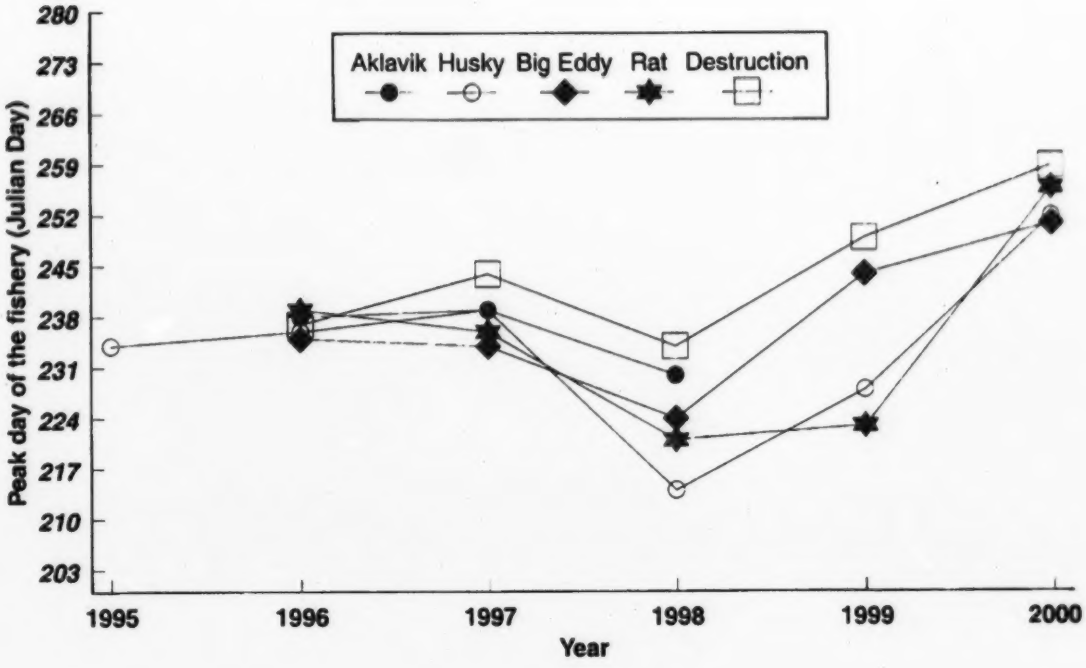

Fig. 3. Annual differences in the peak of the Rat River Dolly Varden subsistence fisheries at sampling/monitoring sites, 1995-2000

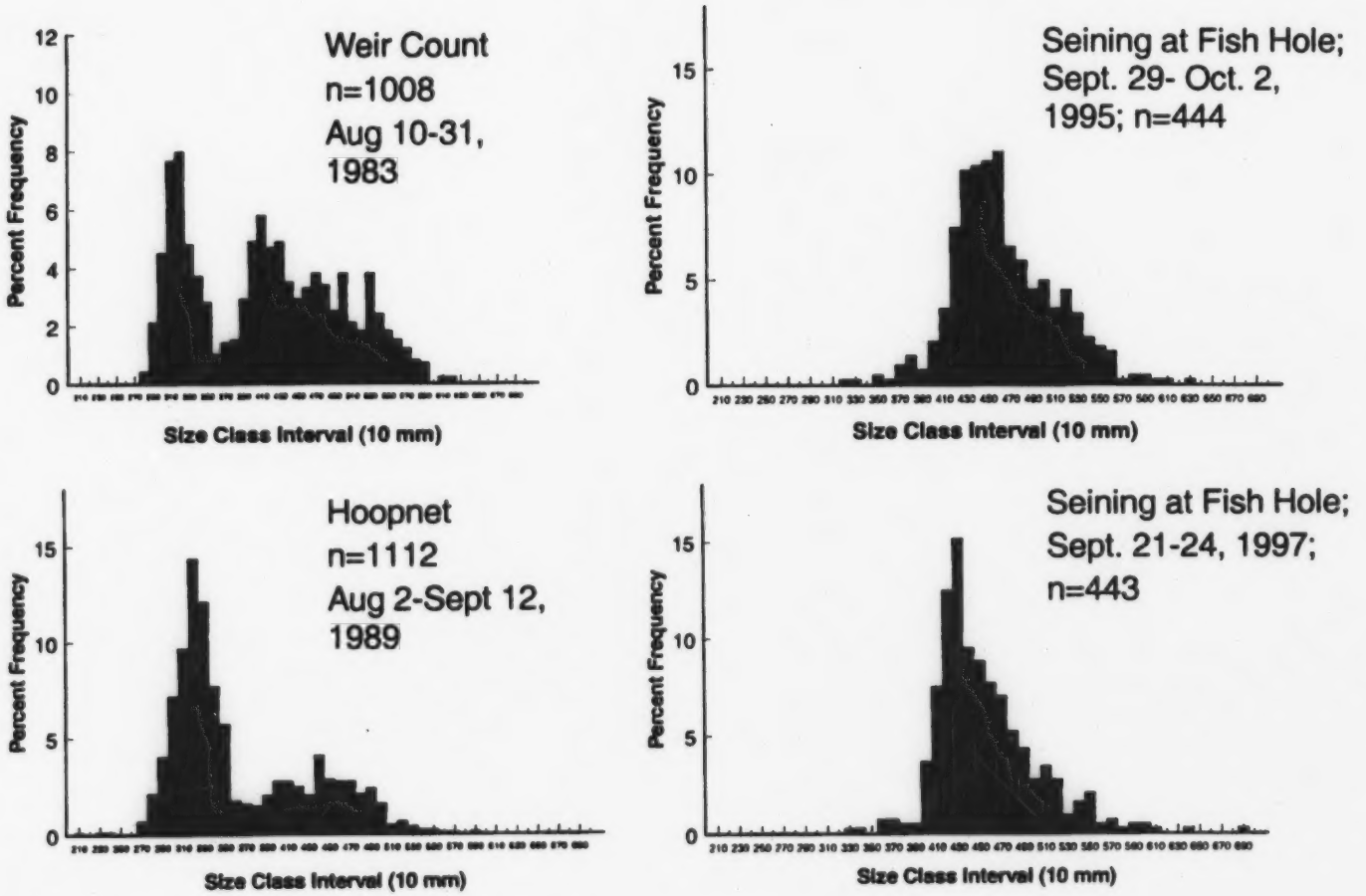

Fig. 4. Frequency distribution of charr fork lengths at the 1983 weir enumeration (Gillman and Sparling 1985), the 1989 hoopnet study (Stephenson and Lemieux 1990), and the 1995 and 1997 spawner assessments at the Rat River Fish Hole, NT (Harwood, L., Sandstrom, S., unpubl. data)

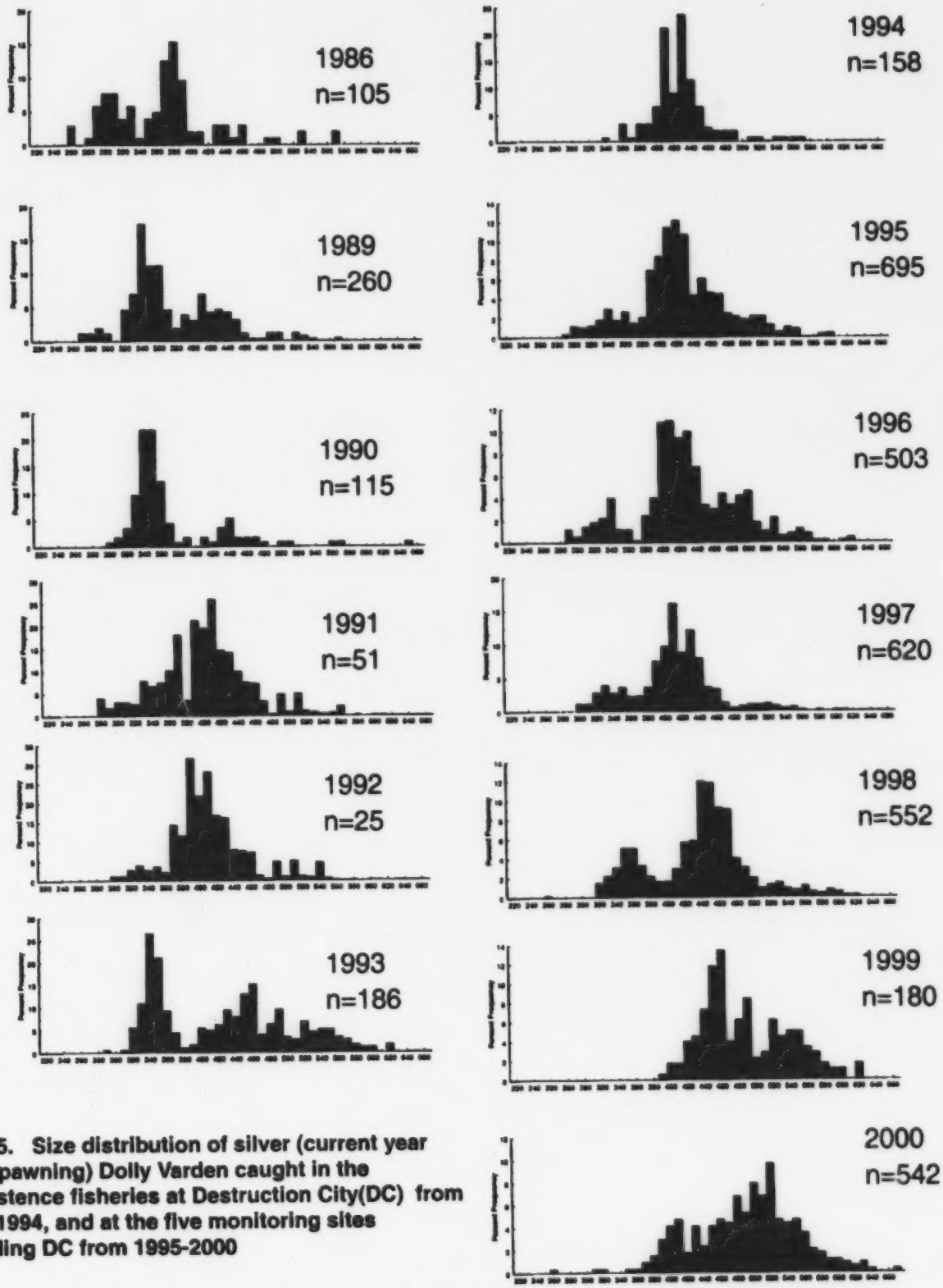

Fig. 5. Size distribution of silver (current year non-spawning) Dolly Varden caught in the subsistence fisheries at Destruction City(DC) from 1986-1994, and at the five monitoring sites including DC from 1995-2000

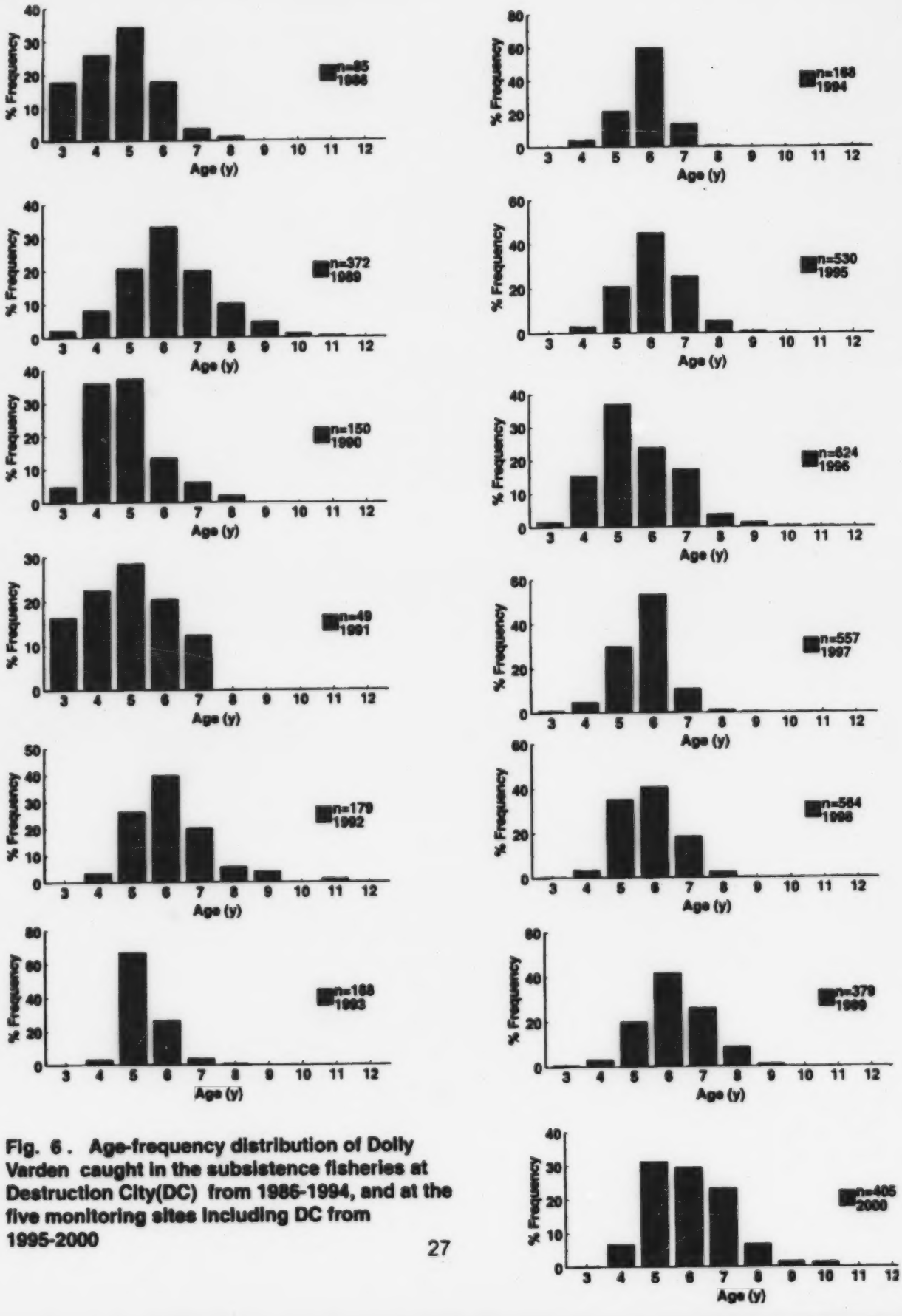

Fig. 6. Age-frequency distribution of Dolly Varden caught in the subsistence fisheries at Destruction City(DC) from 1986-1994, and at the five monitoring sites including DC from 1995-2000

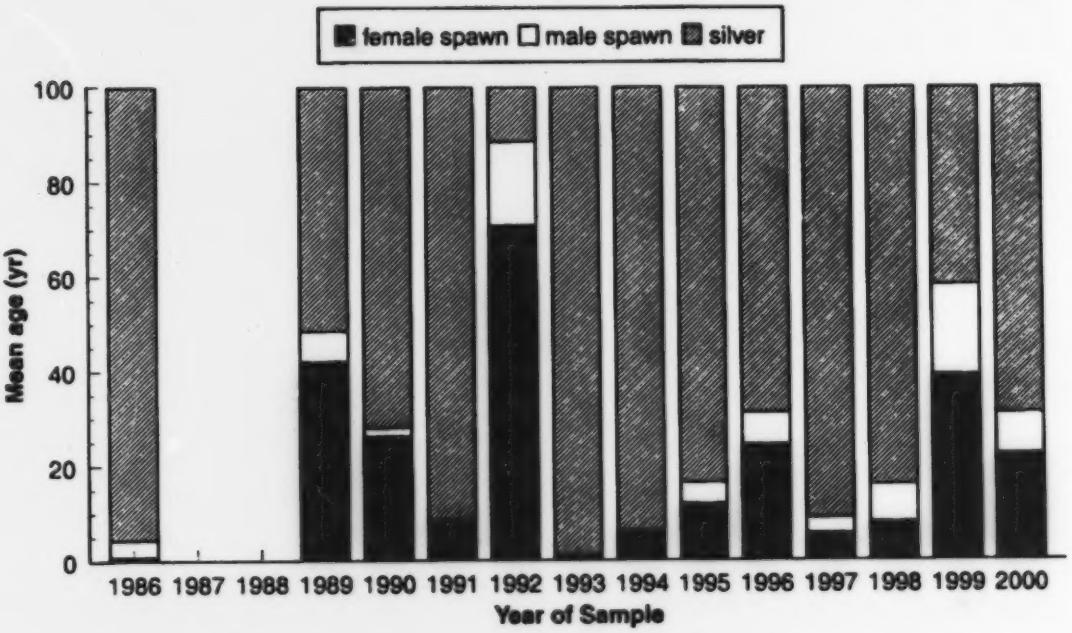

Fig. 7. Relative proportion of current year spawning male, spawning female and silver Dolly Varden in the Rat River subsistence fishery at Destruction City (1986-1994) and at the five charr monitoring sites including Destruction City (1995-2000)

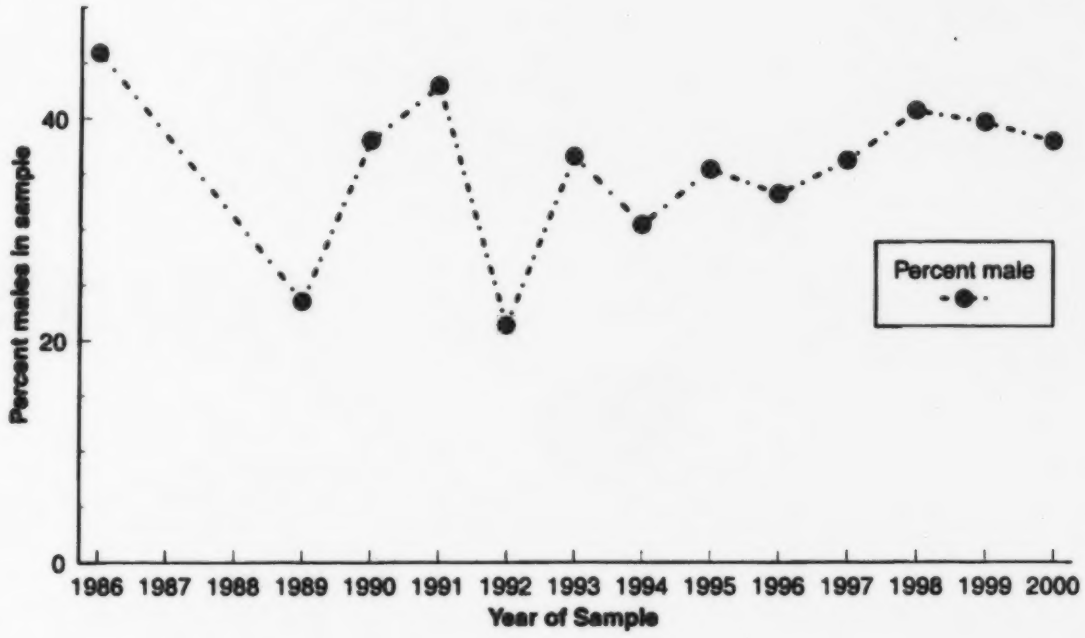

Fig. 8. Relative proportion of male Dolly Varden in the Rat River subsistence fishery at Destruction City (1986-1994) and at the five charr monitoring sites including Destruction City (1995-2000)

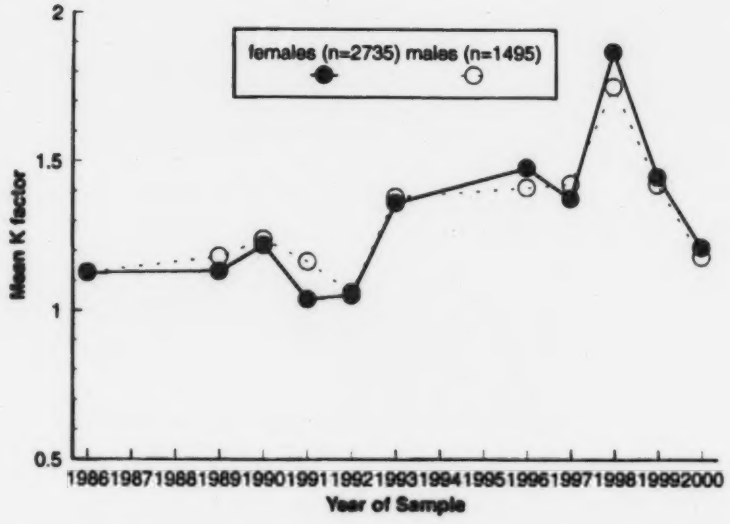

Fig. 9. Mean condition factor (K) for male and female Dolly Varden charr harvested in the Rat River subsistence fishery at Destruction City (1986-1994) and at the five monitoring sites including Destruction City (1995-2000).